AI Planning
Exercise Sheet 7

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Exercise 7.1

(a) $\Pi' = \{V, I, O, \gamma\}$ with

- $V = \{above\text{–}a, above\text{–}b, above\text{–}c, below\text{–}a, below\text{–}b, below\text{–}c\}$
  $\mathscr{D}_{above\text{–}\Upsilon} = \{A, B, C, n\} \setminus \{\Upsilon\}$
  $\mathscr{D}_{below\text{–}\Upsilon} = \{A, B, C, t\} \setminus \{\Upsilon\}$
  where $\Upsilon \in \{A, B, C\}$
- $I(a) = 1$ for $a \in \{below\text{–}b = t, above\text{–}b = A, above\text{–}a = n,$
  $below\text{–}c = t, above\text{–}c = n\}$
  $I(a) = 0$ else
- $O = \{move\text{–}X\text{–}Y\text{–}Z, move\text{–}X\text{–}Table\text{–}Z, move\text{–}X\text{–}Y\text{–}Table\}$
  $move\text{–}X\text{–}Y\text{–}Z = \langle (below\text{–}X = Y) \wedge (above\text{–}X = n) \wedge (above\text{–}Z = n),$
  $(above\text{–}Y := n) \wedge (below\text{–}X := Z)\rangle$
  $move\text{–}X\text{–}Table\text{–}Z = \langle (below\text{–}X = t) \wedge (above\text{–}X = n) \wedge (above\text{–}Z = n),$
  $(below\text{–}X := Z)\rangle$
  $move\text{–}X\text{–}Y\text{–}Table = \langle (below\text{–}X = Y) \wedge (above\text{–}X = n),$
  $(above\text{–}Y := n) \ \wedge (below\text{–}X := t)\rangle$
  for pair-wise distinct $X, Y, Z \in \{A, B, C\}$
- $\gamma = (above\text{–}c = B) \wedge (above\text{–}a = C)$

And the addition[1] that every $above|below[:]= \Upsilon$ with $\Upsilon \in \{A, B, C\}$ implies its counterpart (e.g. $above\text{–}A[:]= B$ also tests/sets $below\text{–}B[:] = A$).

(b) $\Pi'' = \Pi$

The induced propositional planning task Π'' is the (regular) planning task $\Pi'' = \langle A', I', O', \gamma\rangle$, where

- $A' = \{(v, d) | v \in V, d \in \mathscr{D}_V\}$
  $A' = \{(above - a, B), (abova - a, C), (above - a, n), (above - b, A), (above - b, C), (above{-}b, n), (above{-}c, A), (above{-}c, B), (above{-}c, n), (below{-}a, B), (below{-}a, C), (below{-}a, t), (below{-}b, A), (below{-}b, C), (below{-}b, t), (below{-}c, A), (below{-}c, B), (below - c, t)\}$

[1] to make this a bit less verbose and better readable

- $I'((v,d)) = 1 iff I(v) = d$
  $I'((v,d)) = 1 \ \forall (v,d) \in \{below - b, n), (above - b, A), (above - a, n), (below - c, t), (above - c, n)\}$

- $O' = \{move–X–Y–Z, move–X–Table–Z, move–X–Y–Table\}$
  $move–X–Y–Z = \langle (below–X, Y) \wedge (above–X, n) \wedge (above–Z, n),$
  $(above–Y, n) \wedge \neg(above–Y, X) \wedge$
  $(below–X, Z) \wedge \neg(below–X, Y)\rangle$
  $move–X–Table–Z = \langle (below–X, t) \wedge (above–X, n) \wedge (above–Z, n),$
  $(below–X, Z) \wedge \neg(below–X, t)\rangle$
  $move–X–Y–Table = \langle (below–X, Y) \wedge (above–X, n),$
  $(above–Y, n) \wedge \neg(above–Y, X) \wedge (below–X, t \wedge \neg(below–X, Y))\rangle$

- $\gamma = (above–c, B) \wedge (above–a, C)$

(c)

Exercise 7.2

(a) Since both h_1 and h_2 include the blank tile, $h_1 + h_2$ is not admissible.
Proof by counterexample:
$n = 1$, $m = 2$

$$s = \begin{matrix} t_0 & t_1 & t_2 & t_3 \\ t_4 & t_5 & t_6 & t_7 \\ t_8 & t_9 & t_{10} & t_{11} \\ t_{12} & t_{13} & b & t_{14} \end{matrix} \quad \alpha_2\text{-view} : \begin{matrix} t_0 & - & - & - \\ - & - & - & - \\ - & - & - & - \\ - & - & b & - \end{matrix} \quad \alpha_1\text{-view} : \begin{matrix} - & t_1 & t_2 & t_3 \\ t_4 & t_5 & t_6 & t_7 \\ t_8 & t_9 & t_{10} & t_{11} \\ t_{12} & t_{13} & b & t_{14} \end{matrix}$$

$h^*(s) = 1$
$h_1(s) + h_2(s) = 1 + 1 = 2$
$2 > 1$, therefore $h_1 + h_2$ is not admissible.

(b) Basic approach: Goal awareness: for every goal state s_γ of the full puzzle, $h_3(s_\gamma) = 0$ and $h_4(s_\gamma) = 0$. Consistency: since a tile is accounted for in at most one of $\{h_3, h_4\}$, each step necessary to reach the goal counts as either 1 or 0 in $h_3 + h_4$.